



No. 2005–42

A LOGIC OF MULTI-LEVEL CHANGE OF ROUTINES

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October 2004

ISSN 0924-7815

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Paper for the EAEPE conference, Crete, 28-30 October 2004

Summary

This paper tries to account for endogenous change of multi-level routines in terms of nested cycles of discovery, in a hierarchy of scripts. Higher-level scripts constitute the selection environment for lower level ones. On any level, a cycle of discovery proceeds from established dominant designs. When subjected to new conditions, a script first tries to adapt by proximate change, in differentiation, with novel selection of subscripts in existing nodes in existing script architecture. Next, in reciprocation it adopts new nodes from other, surrounding scripts. Next, it adapts script architecture, in novel configurations of old and new nodes. In this way, lower level change of subscripts can force higher-level change of superscripts. In this way, institutions may co-evolve with innovation.

Key words: routines, learning, evolution

JEL classification: B52, D21, D83

Introduction

Nelson and Winter (1982) proposed organizational routines on different levels, with higher-level routines governing the change of lower level routines. How does that work? Can lower level change also create higher level change? The literature on organizational learning recognizes different *levels* of learning. In particular, there is individual learning and organizational learning (Cohen 1991, Cook and Yanow 1993, Weick and Westley 1996). An important link between individual and organizational learning lies in intermediate ‘communities of practice’ (Brown and Duguid 1991, 2001, Wenger and Snyder 2000, Bogenrieder and Nooteboom 2004), as the basic social unit of organization. Clearly, there is a close connection between the change of organizational routines and organizational learning. Organizational learning may be defined as the development of organizational routines.

The literature on organizational learning also distinguishes between different *orders* of learning, called ‘single and double-loop learning’ (Argyris and Schön 1978), which goes back to Bateson’s (1972) notion of ‘first and second order learning’. This seems closely related to the distinction March (1991) made between ‘exploitation’ and ‘exploration’. Exploitation (and first order learning) entails improvements within basic logical structure, principles or design, while exploration (and second order learning) entails that such

principles be broken and replaced. The question is how these two degrees of learning are related: how exploration leads to exploitation, and how exploration arises from exploitation.

For this, Nooteboom (2000) proposed a 'logic' or heuristic of discovery, of how exploration may emerge from exploitation, in different stages of adaptation to novel contexts of action. The key idea was that novel structures arise from a period of experimentation outside of, or protected from, the grip of existing structures of exploitation, in novel contexts of action. It is only after this detour, when novelty has proven its potential and gives indications of how it might be used, that it is able to break through the constraints imposed by incumbent structure of markets and institutions 'in the home niche'. Examples of the movement into niches outside the grasp of incumbent institutions are the seeking of new markets for existing products, new applications of existing theory, entrepreneurial 'spin-offs' from large firms, and the move of a non-mainstream economist into a faculty of business.

The question for this paper is whether we can explain the change of organizational routines, on different levels, on the basis of this 'logic' of change.

The paper proceeds as follows. First, in a theory section it summarizes the theory of knowledge used in this paper, and the 'logic of discovery'. Second, in a conceptual section it discusses the notion of routines, communities of practice and the notion of *scripts* for an elaboration of the notion of routines. This yields a formal definition of organizational routine as an architecture of roles and tasks. From this, the paper derives a hierarchy of levels of change. Third, the paper uses the logic of discovery to give an account of how multi-level change of routines might take place.

THEORY

Theory of knowledge

In a discussion of organizational learning it should be clear what the underlying theory of knowledge is. Here, the notions of knowledge and cognition are taken in a wide sense, including perception, interpretation and evaluation, which includes emotion-laden value judgements. In other words, cognition and emotion (such as fear, suspicion, grief, excitement) are seen as linked (Merleau-Ponty 1964, Simon 1983, Nussbaum 2001, Damasio 2003). Emotions are informed by knowledge and they drive knowledge. In particular, emotions trigger a shift of routinized behaviour from *subsidiary* to *focal* awareness.

It is a truism, in the management literature, to say that information is not the same as knowledge: to become knowledge, information needs to be interpreted and understood in a cognitive framework. Similarly to most researchers in this area, I employ the 'activity theory' of knowledge, and language, taken from cognitive psychology, that intelligence is internalized action (Piaget 1970, 1974, Vygotsky 1962, Bruner 1979, Blackler 1995). This view is related to other 'constructivist', 'interpretative' or 'hermeneutic' views (cf. Weick 1979, 1995). In contrast with the dominant 'computational representational' view in cognitive science, this leads to the view of knowledge in terms of 'situated action'. Knowledge and the meaning of words are not independent from context. They lie partly

in the context of use, and they shift from one context to another. One may still speak of mental 'representations', but only on the understanding that they are mentally constructed, in an embedding in existing cognitive structures and contexts of action, and are not 'given' as any 'mirror image' of reality. Even 'recall' from memory is not simple retrieval, but reconstruction, affected by the context at hand. For a more detailed discussion, see Nooteboom (2000). This process of knowledge construction precludes objective knowledge (or at least any certain knowledge whether or to what extent knowledge is objective). We cannot 'descend from our mind to check how our knowledge is hooked on to the world'.

Personal knowledge is embedded in a system of largely tacit, routinized mental categories that constitute absorptive capacity (Cohen and Levinthal 1990). Since mental categories have developed on the basis of interaction with others, in a string of contexts that make up experience, knowledge is path-dependent, and there will be 'cognitive distance' (Nooteboom 1992, 1999) between people with different experience, and cognitive similarity to the extent that people have interacted, in shared experience. Cognitive distance yields both a problem and an opportunity. The opportunity is that we learn from others only when they see and know things differently. In the absence of claims of objective knowledge, interaction with others is the only means we have to correct our errors. The problem, however, is that due to cognitive distance people may not understand each other, and have to invest in mutual understanding.

In view of this, in a cognitive theory of organization, a central task of organization is to act as a 'focusing device', to sufficiently reduce cognitive distance, and to bridge remaining distance, in order to combine knowledge for collective goals (Nooteboom 1992, Kogut and Zander 1992). The downside of such organizational focus is that it creates organizational myopia, which needs to be corrected in outside relations with other organizations with complementary views of the world, to benefit from 'external economy of cognitive scope' (Nooteboom 1992).

A logic of discovery

The theory of discovery adopted from Nooteboom (2000) tries to connect exploitation and exploration. Exploitation follows from exploration, but also forms the basis for it, somehow. The theory aims to show how this might work. A central idea is that in order to maintain exploitation as much as possible during exploration, organizations will proceed from less to more radical forms of change. In other words, stability is preserved as much as possible. One does not engage in change until both the promise (potential) and the feasibility of such change has become manifest.

In a nutshell, the basic logic of the theory is as follows:

To arrive at radically new insights, one needs to escape from the established institutional order of existing insights and practices that have been made into the norm. It is like crime and the transgression of limits more in general: one needs opportunity, motive and means.

One may have to escape from the sway of the established order, and its attendant conformism (Dimaggio and Powell 1983), in order to get the *opportunity* for deviation that is seen as deviance. This can take several forms, such as: the location of R&D in a separate department, an entrepreneurial spin-off from an established firm, the flight on a non-orthodox economist into a business faculty, drop-out from school, protection of infant industries, a sidestep into a niche market. Here, emergent novelty may have to be protected from competition.

This transfer of a practice into a new niche is called the stage of *generalization*. In learning theory, this corresponds with the idea that a switch of perspective stimulates learning (see the work of J. Bruner and J. Piaget). The new selection environment yields new conditions for survival, and hence pressure for adaptation. This yields the *motive* for change, and the legitimation of deviance. For example, consider the position of a foreign subsidiary of a multinational company. It can use the need of local adaptation as an argument to deviate from procedures or standards customary in the home country. In the new environment it is rational to first try marginal or proximate adaptation, maintaining exploitation as much as possible, while yet setting out on a path of exploration. For this one taps into memory of experimentation that preceded the present dominant practice. This is called the stage of *differentiation*. Here the memory and experience of older staff are of great importance, to recall trials and designs that were selected out in the selection environment at home but might be reconsidered in the novel niche.

Next, if proximate adaptation does not suffice for survival in the new niche, the *motive* arises for more radical change. In the new niche one has run into different, local practices, gaining insight into their apparent success where one's own practice fails. This yields the cognitive *means* for change, in the form of hints of what new elements might be useful. This leads to experiments in the adoption of foreign elements into one's own practice, in the construction of *hybrids*. This is called the stage of *reciprocation*.

The history of technology gives many examples (Mokyr 1990). It is interesting also that insights from neuroscience (Edelman 1987, Holland et al. 1989) indicate something similar, in 'reciprocation', i.e. mutual 'borrowing', between neural groupings, in the development of new ideas in 'neuronal group selection'.

This stage of reciprocation is crucial, in experimentation with novel elements while trying to maintain the basic logic or structure of existing practice. In this way, room is given for novel combinations that are as yet not too destructive. Here, the subsidiary of the multinational demonstrates that it is still doing its utmost best to remain within the established order imposed by the central office.

Next, it becomes increasingly difficult to continue such change, in hybridization, while maintaining the basic logic or structure of dominant practice. Hybrids become inefficient and self-contradictory. Within established structure, duplications and redundancies of elements occur, which block opportunities for pooling activities for the sake of economy of scale. Marginal returns of further additions decline. This gives the *motive* for more radical change, also in basic principles and design, in novel combinations of both elements and design principles. This stage is called *accommodation*.

Here, the foreign subsidiary of the multinational can boast evident success, while also being able to show that more radical departures from established order are needed to

realize the full potential of the novelty, and that this is likely to be worth the costs and efforts of repercussions in the larger system of the corporation.

In this stage it is important to break through the conservative pressures of established interests, and eliminate entry barriers. In economies, this is where competition policy must do its job.

Here, there are two connections with evolutionary theory. First, with the notion of ‘allopatric speciation’ proposed by Eldredge and Gould (1972): new species typically evolve at the edge, or outside of, the parent niche. The analysis explains the empirically documented, but as yet unexplained, phenomenon of ‘punctuated equilibria’ in economics (Romanelli and Tushman, 1994): radical change of incumbent practice often requires a long detour of experiments outside the established order, from proximate to more radical change.

A second connection with evolutionary theory concerns the co-evolution of novel species and the selection environment. When a radical novelty enters an existing selection environment of markets and institutions, the latter need to be transformed in order to let the innovation achieve its full potential. This yields a view of endogenous institutional change ‘from the bottom up’.

An example of such institutional change is the emergence of the multi-media industry (Gilsing and Nooteboom 2004). This was preceded by the integration of information- and communication technologies (ICT), and the emergence of Internet, which largely occurred outside the scope of the existing media industry. When its technical potential became clear, applications to media were developed, still largely outside the media industry, partly by spin-off firms from that industry by entrepreneurial workers who encountered insufficient response to their ideas within the traditional firms. Now that new media are developing, publishers have to follow and adapt or perish in the new selection environment that is emerging to accommodate the potential of ICT and Internet.

ROUTINES, COMMUNITIES AND SCRIPTS

Routines

Routines entail behavioral regularity, repetition, and stability (Becker 2003). Here, I adopt the definition of an organizational routine as a kind of collective habit (Hodgson 2004) in the form of a ‘capability for repeated performance in some context that has been learned by an organization’ (Cohen and Bacdayan 1996). In Aristotelian terms, a routine is not act but a potentiality for actions (Hodgson 2004). It serves as a basis for activity, but, I will argue, also develops from it. In contrast with Hodgson (2004) I allow for individual next to collective, organizational routines. A routine is conditional upon context, in the sense that it is geared to a kind of context and is triggered by cues from the context.

Routinized behaviour, of individuals and collectives, is typically ‘automatic’, in the sense of unreflected, and largely based on tacit knowledge, in ‘subsidiary’ rather than ‘focal’ awareness (Polanyi 1962, 1966, 1969). Here, the notion of routines connects with Simon’s notion of routinized behaviour. As argued by Herbert Simon, tacit, routinized mental routines are rational in the sense of being ‘adaptive’: they help us to function and

survive in a world of uncertainty and bounded rationality.¹ Activity becomes routinized when it has proven to be consistently adequate, or ‘satisficing’. The routine is relegated to subsidiary awareness. The downside of routines is that they may become dysfunctional in novel circumstances. When this yields a perceived threat, due to malfunction, routinized behaviour may be shifted, at least to some extent, from subsidiary to focal awareness, for critical, deliberative reflection. As argued by Simon (1983) emotions, such as fear, caused by malfunction, serve to trigger such a shift. This is one reason why emotions are part of rationality, in the sense of adaptiveness.

Routines differ from rules. While rules regulate behaviour, and routines generate behaviour, this is not necessarily the same. First, rules are canonical (Cohen and Bacdayan 1996), i.e. codified and decontextualized, with an implicit claim of being complete and context-independent. Organizational routines are incompletely codifiable, largely implicit, tacit, procedural, and geared to and embedded in specific contexts of action. Rules can be absorbed into the development of a routine, but this entails additions and amplifications of tacit application knowledge, and variations upon the rule. In a process of canonification, rules are often abstracted from context-specific routines into generalized prescriptions. The advantage and purpose of this is that they may then be disseminated across a variety of contexts. Their shortcoming is that they are not rich and malleable enough to cope with the complexity and variability of specific contexts of action. That is why ‘work to rule’ is a form of sabotage. Second, rules are explicitly normative, while routines are more implicitly so. When expressed at all, routines tell us ‘how we do things’, but they carry the illocutionary or conative force of ‘this is how things are to be done’. New entrants to a community are socialized into its routines. Because they are highly tacit and habitual, routines are taken for granted and difficult to subject to rational criticism. This is a familiar problem in smaller firms, where routines tend to be more tacit and implicit than in large firms, where they have to be specified and codified into rules in order to coordinate actions across different locations and functions. Before routines can be subjected to criticism, they may have to be made more explicit.

What is the ontological status of an organizational routine? As noted by Becker (2003), we need to distinguish between routines as (potential) behaviour, and routines as (mental or other) representations of such behaviour. On the level of individuals a routine is represented, i.e. embodied, in a constellation of bodily and mental processes. Organizational routines drive patterns of collective action. They are embedded in social structures and minds of participants. Organizations may have non-mental, codified, abstracted representations of some collective routines, documented in organization charts, job descriptions, standard operating procedures, algorithms, blueprints, and the like. Organizations do not have tacit knowledge other than that of individuals. Individuals have mental representations of parts of organizational routines, typically the parts in which they are involved. Next to mental representations of behavioural routines, people have mental routines. Mental routines may have no mental representations, and are always partially tacit, embedded in minds that operate as ‘seamless webs’ (Quine 1960) of cognition.

¹ Here, I distinguish two meanings of ‘rational conduct’. One refers to the use of reason for deliberative evaluation, in ‘calculative behaviour’, and the second refers to the adaptiveness of conduct, contributing to survival under uncertainty.

Communities of practice

‘Communities of practice’ (COP) have been proposed as a crucial intermediate level, between individuals and organization (Brown and Duguid 1960, 2001, Wenger and Snyder 2000). In their characterization of COP’s, Brown and Duguid (1960: 60) employ the ‘activity-theory’ of knowledge summarized before, in which action and learning are intertwined, and they view ‘learning as a bridge between working and innovation’. They employ the notion of canonical and non-canonical or ‘procedural’ (Cohen and Bacdayan 1996) knowledge. The latter may be codifiable to some extent, and this may serve as a basis for teaching, but such teaching has to be followed by training, in ‘peripheral participation’ (Lave and Wenger 1991), for adequate participation in an organizational routine.

It is by context-dependent deviations from canonical rules, with the ensuing need for improvisation and experimentation (Brown and Duguid employ Levy-Strauss’ concept of *bricolage*) that learning arises, in a change of routines, in interaction between members of the community. This is based on ‘storytelling’, to capture and share context-bound experience, to guide experimentation. As a result, communities, and routines, emerge from shared work practice rather than that they are designed *ex ante*.

Scripts

In order to further develop the notion of a routine, I employ the notion of scripts, which, like routines, I apply to individuals as well as organizations (Gioia and Poole 1984, Nooteboom 2000). Originally, the notion of scripts was proposed on the level of personal mental constructs (Shank and Abelson 1977). A script is an ordered structure (*architecture*) of component activities called *nodes* in the script. The collection of nodes may be compared to what Pentland (2003) (quoted in Becker 2003) called the ‘lexical variety’ of a routine, and architecture may be compared to what he called ‘sequential variety’ (except that here structure is not limited to temporal sequence). On an organizational level, in organizational rather than mental scripts, nodes refer to local ‘communities’ or individuals. Nodes in a community script entail *repertoires* of (potential) activities of individuals in that community, which are modelled here as subscripts. An organizational script, in turn, contributes to one or more nodes in an industrial superscript. In this way, the notion of scripts, with super- and subscripts, yields a convenient conceptualization of a multi-level system of routines. In other words, I propose a multi-level system that is, in mathematical terminology, fractal. This is illustrated in Figure 1.

Figure 1 about here

Here, the notion of scripts is used to model routines. While routines entail what people actually do, scripts are imperfect, canonical representations of routines. No specification of a script can exhaust what goes on in a routine. Scripts are identified by ‘tags’ (Holland

1995), which may be short descriptions or icons representing what they do. These are used in the search for and triggering of scripts.

In a script, there are direct connections or 'ties' between nodes when their activities are dependent in some way. Thompson (1967) distinguished between 'sequential interdependence', 'pooled interdependence', where different units exploit or produce joint resources, and 'reciprocal interdependence', which entails concerted effort: the effort of all members must be performed in synchrony.

The pattern of ties that a node has with other nodes define its *role* in the structure. In other words, the architecture of a script defines a set of roles. Neighbouring nodes, i.e. nodes with direct ties of dependence, exert demands on each other, which yield *constraints* on their activities. These constraints define the *task* of a node. In other words, a role entails a set of ties and tasks to satisfy the ties. The setting of constraints on tasks entails the setting of *validation criteria* for activities in a collective endeavour. The process of *validation* entails the determination of such constraints on linkages, i.e. tasks. Each node entails one or more subscripts (which together form a repertoire) for the activities that are contributed by the node to the script. For an individual, such a repertoire constitutes his *capabilities*.

People have mental representations of their own repertoires, and of at least part of the collective structure of action. The mental representations that people have, even of their own, individual routines, are not complete, they may be over-complete, in the sense that they may include elements that do not actually form part of their routines, and they may be in error, in the sense of distorting what actually happens. Individuals have mental representations of a collective script that may be very incomplete. Concerning other nodes in a collective script, people need to know at least the constraints on ties with neighbours. In other words, they must know their own role and tasks. They may or may not need to know about the repertoires of routines in other nodes. I will return to that later. If they have a representation of the repertoire of routines of another node, those also may be incomplete and incorrect.

Ambiguity

Here, scripts are used as models of individual and collective routines. Philosophically, it is problematic to talk of scripts as 'existing' objectively. A script may be said to exist, in the routine that it models, but how do we know that we model the routine correctly? To avoid awkward, contorted language, I will talk of scripts as if they 'exist' as adequate representations of routines. However, as noted before, routines are characterized by being procedural rather than canonical, and open-ended rather than closed. That is why in the literature scripts have been criticized as being too closed, determinate and canonical, and it has been proposed to replace them by 'stories' that allow for more ambiguity (Shank and Abelson 1995). This does not mean that in their later work Shank and Abelson (1995) rejected scripts:

'A script is a set of expectations about what will happen next in a well - understood situation. In a sense, many situations in life have the participants seemingly reading their roles in a kind of play. Scripts are useful for a variety of reasons. They make clear what is supposed to happen and what various acts on the part of others are supposed to

indicate. They make mental processing easier, by allowing us, in a sense, to think less. You don't have to figure out every time you enter a restaurant how to convince someone to feed you. All you really have to know is the restaurant script and your part in it. Scripts are helpful in understanding the actions of others as long as we know the script they are following' (p. 5). However: 'Situations that one person sees as a script may seem quite open - ended to another person'.

The classic example of a script is a restaurant script (Shank and Abelson 1977). It is a collective script for the overall operation of a restaurant, with nodes of individual activities of both staff and customers. It orders component activities of entry, seating, ordering, cooking, serving, eating, paying and leaving. As in this case, more generally a script is not fully deterministic, since it does not cover all that may happen. It allows for variations within its nodes. For example, one might employ different modes of payment (cash, credit card, debit card, chip card). In some cases the technology of chip cards has not been installed, and some restaurants may not accept credit cards. The restaurant script is social, being shared between individuals, but individuals may have non-identical mental representations of it, and they may have different experiences associated with it. That is part of cognitive distance between people. Some customers may be used to taking a dog with them, but this is not always allowed. It may be included in their mental script of a restaurant, but not in the mental scripts of the staff of a specific restaurant.

Absorptive capacity

The notion of a mental representation of a script, can be used to elaborate the notion of absorptive capacity (Cohen and Levinthal 1990): individuals can absorb what they can fit into a relevant mental script. An important feature of a mental script is attribution: in a relevant context the observation of one node may trigger the entire script in the mind, by picking up its tag, and unobserved nodes are carried along in attribution. This is one way in which cognition is context-dependent: the context determines which scripts are triggered. This is efficient, for fast pattern recognition, but can yield prejudice. Thus, mental scripts create but also limit absorptive capacity.

Recently, in a hotel in Strasbourg I picked up an egg from the breakfast buffet, thinking it felt a bit cold, but then boiled eggs do tend to get cold when one comes down late. Subsequently, I created a gluey mess when blithely chopping off the top of an unboiled egg. Going back to the buffet I saw, for the first time in my life, a machine for boiling eggs. The purpose and procedure were stated clearly, in French. I had not noticed since it was no part of my buffet breakfast script.

Individual absorptive capacity is constituted by mental representations of one's scripts of action, and of parts of superscripts pertaining to one's role, tasks, and, possibly, the roles and tasks of other nodes in the collective script. Mutual absorptive capacity between people entails that they can understand each other's actions, and take appropriate action from their repertoires.

Collective, organizational absorptive capacity entails the ability of the community to absorb events into collective script (such as actions of customers in the restaurant script).

It is constituted by the totality of individual and collective rules and routines, and the collective ordering of those, in 'distributed cognitive systems' (Hutchins and Klausen 1996, Tsoukas 1996).

FLEXIBILITY AND MULTILEVEL CHANGE

Change of script

In terms of scripts the cycle of discovery can be specified as follows:

In *Consolidation*, old scripts have been broken up, and in that sense competencies have been destroyed. There is no longer a dominant design that operates as a selection environment for subscripts. A novel, emerging script is indeterminate in the sense that the identification and configuration of nodes (architecture), and appropriate repertoires of subscripts in nodes are unstable: best practice is not yet clear. In other words, roles and tasks are not yet clear. The novel script is still messed up with mismatches between elements combined from earlier scripts, in attempts at novel combinations. Nodes or subscripts are included that do not fit well, or nodes are put in an inappropriate configuration. There is no existing norm or model to identify this, and increase of effectiveness or efficiency is a matter of learning by experimenting. However, options are constrained by superscripts in which the emerging script has to fit. As experimentation proceeds, more insight is gained from repeated trials in the context from which the new script is emerging. By experimentation, the best selection and configuration of nodes are established, and this yields a 'dominant design'. Efficiency increases by the elimination of redundant nodes and inappropriate subscripts, and a narrowing down to optimal and parsimonious procedures. This yields increasing efficiency, along 'experience curves' (Yelle 1979). This is my rendering of the notion of 'first order' (or 'single loop') learning. Once such a dominant design has been established, it functions as the new selection environment for lower level activities.

Later, in *generalization* the script is applied in novel contexts, which may be either actively sought or may be imposed from outside. The dominant design provides a prototype upon which variations can be made, depending on the context. As the script is applied in novel contexts, *differentiation* occurs to adapt to the new context. Old branches of scripts, eliminated in the period of experimentation prior to consolidation, but remembered, may be revived. The most proximate form of differentiation, preserving script architecture, is parametric change by substitution of different subscripts from the repertoires of activity associated with nodes. For example: to adjust for differences in capabilities or desires of customers, in the new context, or capabilities of labour, sources of energy, available materials, technology of maintenance and support, technical standards, etc. Together, the stages of generalization and differentiation can be seen as 'incremental' innovation, which is cumulative: building upon past performance.

Next, as anomalies and misfits accumulate further, the limits of the script's potential become visible, and observations accumulate which indicate that elements (nodes) from other practices (scripts), encountered in the novel context, while performing similar functions, appear to perform better. They are seen to eliminate shortcomings or offer opportunities for satisfying new demands. This leads to the borrowing of subscripts from

those nodes, and next the adoption of entire nodes, in the architecture of existing practice, in *reciprocation*.

As differentiation and reciprocation proceed, scripts become messy, inefficient and inconsistent. Novel subscripts or nodes (entire repertoires of subscripts) put strain on the script's architecture: they do not fit in the existing ordering of nodes and associated conditions imposed on inputs into and outputs from nodes. In other words, they yield conflicts in roles, tasks and capabilities. Above all, novel subscripts or nodes are not utilized to their full potential, due to constraints imposed by existing architecture. To allow for their full utilization, tasks have to be modified, but this has implications for tasks elsewhere, or even for roles. The same nodes may appear at different locations in the architecture, or different nodes may have overlapping repertoires, yielding duplication, redundancy, opportunities for utilizing economy of scale are missed, and there is an accumulation of anomalies and misfits. Due to increasing complexity of structure, due to overlap and duplication, there are diminishing returns in further importation of novelty. The complex spaghetti of linkages makes comprehension and control difficult, and there is an explosion of mutual adjustments and work-arounds to keep the whole running. All this yields pressures for a more fundamental re-design. Changes reverberate through the architecture, in several iterations, leading up to a novel architecture. Subscripts are re-assembled into new nodes, and nodes are reconfigured into new architectures. Here we are back at the initial stage of consolidation. During consolidation a novel 'technological regime' develops (dominant design), with documented knowledge and standardized procedures. The elaboration of the cycle of discovery in terms of script formation is illustrated in Figure 2.

Figure 2 about here

An illustrative innovation is that of self-service retailing. In a service store, customers are stationary, waiting at a counter, while the staff scuttle about to collect the orders. In self-service this is switched: customers wander along the isles to select the goods, while the staff are stationary at a check-out, except in moments of slack demand, when they replenish stocks on shelves. This yields a number of economies. Time spent by customers is substituted for time spent by staff. One can have a larger shop surface with more goods (in service, staff would need to run up and down too large distances). Shelves can be stocked at times of low custom, large volume of sales reduce the pressure of 'threshold costs' (Nooteboom 1982), and both improve the utilization of both labour and space. Walking through the shop, customers may receive an impulse to buy more than they would have without inspecting the shelves. Inspecting goods on the shelves is more enjoyable for the customer than waiting at the counter.

There were several new outside conditions that enabled the innovation. Due to increased consumption and advertising customers had become sufficiently familiar with goods to no longer need advice from attendants, new packing technology enabled pre-packaged goods for display, home refrigerators and freezers and cars enabled customers to buy in bulk.

Note the switch of the basic logic of architecture. Certain nodes of activity (gathering goods) are switched from attendants to customers, stationarity is switched from customers to attendants at the check-out, space (for customers to walk around) is substituted for labour (of attendants collecting goods).

Degrees of flexibility and levels of change

With the notion of a script, we can now identify different kinds or ‘levels’ of flexibility and change in organizational routines. To deal with types or degrees of flexibility, the literature has offered the distinction between *stand-alone*, *modular* and *systemic* structures (e.g. Langlois and Robertson 1995). In terms of scripts, these notions can perhaps be specified as follows. In stand-alone structures, nodes are highly autonomous, in the sense that the connections between them are sparse (non-dense), i.e. they have limited roles. This structure allows for a wide scope of individual variation, on the node level, without jeopardizing the integrity of the script. As a result, there is scope for combining exploration with exploitation. Modularity may be interpreted as standardized constraints on tasks that are furthermore not tight, allowing for a variety of nodes (modules) that can be fitted into the script while maintaining tasks and roles. Modularity entails less flexibility than the stand-alone structure, since here roles may be multiple. In a systemic structure, which is perhaps synonymous with a ‘complex’ structure (Becker 2003), there are one or more of the following features: large number of nodes, high density of ties between them, i.e. roles are multiple, with tight constraints on them, i.e. narrow tasks. This yields problems for exploration within the role without jeopardizing systemic integrity for exploitation. Let us examine different levels of flexibility and change in more detail.

1. Change that preserves existing architecture, existing ties (roles) and constraints on ties (tasks).
 - 1a. with *new selections*, within nodes, from existing individual repertoires of subscripts (capabilities)
 - 1b. with new capabilities, i.e. *new subscripts* (capabilities) in individual repertoires, from individual learning or from entry of new participants with different capabilities. At this level of change, incoming staff would have to learn to satisfy existing roles and tasks, by socialization and instruction.
Flexibility, i.e. scope for change, on this level depends on the tightness of tasks, i.e. of the constraints imposed on allowable subscripts. It can be large when roles are few (stand alone) and/or tasks are not tight (modular). However, it also depends on the range of existing repertoires (1a) and on ease of entry by outsiders (1b).
2. Change that preserves existing architecture and existing linkages (roles), with new repertoires (subscripts), from individual learning or new staff, which yield a *change of constraints (tasks)*, i.e. new validation.
 - 2a. *only local* change of constraints for individual nodes (isolated tasks)
 - 2b. change of constraints (tasks) *throughout the architecture*
Here, flexibility can be large when there are few nodes *or* low density of ties between nodes (few roles), i.e. structure is stand-alone. However, it also depends on the range

of repertoires in nodes, so that nodes can adjust to a change of tasks by new selections from existing repertoires.

3. Architectural change with existing nodes and repertoires, in new linkages (roles). Generally, new linkages will entail new constraints (validation). Here, flexibility can be large when there a few nodes *and* low density of ties. However, it also depends on the scope of repertoires that nodes command, to allow for new configurations of tasks, and on the scope of new architectural principles one can experiment with.
4. New architecture of old and new nodes, including new capabilities (repertoires), with new linkages (roles) and new constraints (tasks). Here, flexibility can be large under low density of ties, but it depends on the scope of nodes and architectural principles to choose from, arising from outside contacts.

To illustrate the framework, let us ask which type of change occurs in varying project teams of specialists. If different specialists enter with different capabilities (repertoires of subscripts) but in fixed roles with fixed tasks, we have type 1 b. If they have different capabilities, and they are given new tasks, but in the same roles, we have type 2a if there is a change only in their individual tasks, and 2b when tasks change across the whole team. If they enter with existing subscripts in new roles, in a new team structure, we have type 3. If there is a new team structure, with new roles and development of new subscripts (capabilities), we have type 4.

A survey of changes for different levels of exploration is given in Table 1.

Table 1 about here

This framework can be seen as a refinement, in terms of scripts, of earlier work, such as:

- the work of Henderson and Clark (1990), who recognized similar types of innovation: change that preserves both elements and architecture (1), change of elements in a given architecture (2), change of architecture of existing elements (3), and new architecture with new elements (4).
- the notions of stand-alone, modular and systemic structures
- the notions of differentiation, reciprocation and accommodation, from the cycle of discovery.

Levels of knowledge and learning

Different levels of change require different types of knowledge and learning.

For change type 1a (Table 1), with preservation of architecture of roles as well as tasks, it is not necessary for everyone to know what everyone knows. All one needs to know about others is who one's neighbours are (one's role), and constraints imposed on ties with them (one's tasks), in order to guard the validity of one's actions. In terms of

shared beliefs, everyone needs to share beliefs *only on existing criteria of validity* (the constraints), *only with existing neighbours* in the collective script. No causal beliefs are needed concerning the repertoires of even neighbouring nodes, as long as they satisfy existing constraints. Here, people are transacting rather than interacting.

In change type 1b it may be a little different. There, individuals learn, i.e. extend their repertoires, or new individuals come in, and they have to be socialized into the community (in 'legitimate peripheral participation'). A potential problem here is that new options arise from individual learning or entry of outsiders, whose use may require adaptation of constraints in ties with one's neighbours. Then, we move to a higher level of change, of type 2a.

In change type 2a, new repertoires require only local adaptation of constraints (*validation*). For this, one requires some knowledge of repertoires of neighbouring nodes, in so far as needed to conduct new validation (new constraints), in mutual interaction. This requires some knowledge of what neighbours know. Knowledge only of the tags of neighbouring scripts may suffice. For mutual adaptation one may need to know something of the content of neighbours' scripts. That requires a certain mutual absorptive and communicative capacity. In terms of shared beliefs, this entails the development of *some shared causal beliefs*, concerning repertoires of action, in so far as necessary for validation, but only between neighbours. A potential problem remains: what if as a result of mutual adaptation neighbours, in turn, need to adapt constraints with their neighbours, resulting in a more pervasive change of constraints, in a collective validation process? This is more likely to occur as the structure of the organization is more systemic rather than stand-alone.

This yields change type 2b. It requires mutually consistent validation in multiple connections (across many roles). This requires either some *central agent* to coordinate multiple validation, or *discussion with all other participants*. Here, there is a need to develop collective knowledge of repertoires (*location and content knowledge*), for which there need to be shared causal beliefs, but only limited, in so far as needed for collective validation. One also needs collective beliefs on *norms for interaction*, and on the overall *architecture* of the collective script. A potential problem remains: what if in the existing architecture no overall consistent validation can be achieved, and the architecture of the collective script needs to be changed to achieve coherence?

This yields change type 3, in architectural innovation with existing nodes and their repertoires, with new ties. As in type 2a, there needs to be collective knowledge, in every node, or in a central pool of knowledge, of the location and *content of all individual repertoires*, and *norms for the conduct of mutual adjustment*. However, more extensive new knowledge of individual repertoires and procedures is needed than in change type 2, because mutual adjustment goes beyond existing neighbours, to allow for novel ties. While in existing linkages norms of interaction have stabilized, this may have created an 'in-group' ethic and feeling that now have to be loosened to allow for 'out-group' linkages. Also, a *new collective enterprise* has to be developed, in a new collective script. 'Collective enterprise' refers to basic beliefs or 'organizational focus' (Nooteboom 1999) concerning the organization, its purpose and style of doing things, which constitute organizational identity, i.e. the organization as a cultural entity. A potential problem here is that to enable a newly emerging script, repertoires in nodes have to be adapted to allow

for the new linkages that it requires. In other words, it may require individual learning, or the introduction of new staff with new knowledge.

This yields exploration type 4, with a change of both individual knowledge, in new repertoires, and the development of a new collective script. Here we have a chicken-and-egg problem. Existing repertoires may need to be adapted, but one can identify potential linkages, for a new script, only on the basis of existing repertoires. So, an *iterative process* of mutual adaptation is needed. This requires iteratively adapted knowledge on the collective script, aims of collective enterprise, norms of interactive conduct, and individual repertoires. This iterative process indicates, precisely, the relation between individual learning (change of subscripts, on the basis of mutual adaptation) and collective learning (formation of a new collective script). In this process, people need to communicate their own repertoires of scripts to others, absorb what they communicate about theirs, they may need to adapt their individual repertoires, and they need to adapt their mental scripts concerning collective script architecture. New norms for conduct have to be developed, iteratively, and new shared views of collective enterprise. That constitutes the core of what was earlier called the ‘focus’ of an organization, which is closely related to organizational identity. At the highest level of change, an organization would thus have to change its identity.

In sum, the analysis of change on different levels of exploration indicates different kinds of knowledge: on validity of actions, on architectures of roles, location of knowledge across roles, content of knowledge (causal beliefs) in repertoires of action, norms of conduct for mutual adjustment, and basic beliefs concerning collective enterprise. Table 2 summarizes what types of knowledge need to be reconstructed at different levels of exploration.

Table 2 about here

Nested cycles of discovery

The question now is what triggers multi-level change. I propose that it may be driven by the cycle of discovery. I propose that multi-level change may arise ‘bottom up’, in nested cycles of discovery on different levels, with the turnaround of the cycle of discovery speeding up as we descend to lower levels, from organization to communities to people. On the level of individual behaviour of people conducting tasks in a community, turnaround of the cycle in mental scripts is in terms of minutes up to hours, on the level of communities days or weeks, on the level of the firm months to years, and on the level of industries decades.

On the lowest level, in executing the subscript of an activity in their repertoires of actions, associated with a node in a community script, individual people may be confronted by novel conditions, either sought or imposed, which yield the need or opportunity to adapt. The novel condition may be the entry of a new participant in the community, which upsets existing roles or tasks, or the need to adapt to new customers, technology, suppliers, etc. According to the cycle of discovery, adaptation is first tried in the proximate change of differentiation, by selecting a different script from available

repertoire. If this does not suffice, improvisations may be made by reciprocation between scripts in available repertoire. When that does not suffice, reciprocation may arise from comparison with scripts from the repertoires of other members of the community. Next, reciprocation may arise with outside scripts encountered in the new conditions. This may derive from a new member entering the community, interaction with other communities in the firm, or new technologies, customers, or suppliers. This may lead to radical change (level 4) of subscript.

On the level of the organization, no change is in evidence as long as the community stays within its assigned tasks. This depends on how tight the task constraints are. Radical change of a subscript may violate those constraints, and this is in the first approach, intolerable. It requires negotiation with connected nodes, i.e. outside individuals or communities in the firm. Mutual fit may be re-established by other nodes engaging in differentiation, i.e. other selections of scripts in their repertoires. In other words, the highest level of change on the individual level (level 4) constitutes the lowest level (1a), in mere differentiation, on the level of the community. However, the inventor of the new action may be able to convince his environment that a change of task, by a shift of constraints, across different nodes, may yield such an improvement of performance that the repercussions of change in tasks in linked nodes are worth while, in exploration level 2a, when the task is relatively stand-alone, or 2b, when structure is more systemic. This is how structural change may arise from below. If no such re-alignment can be achieved, the new heterodox subscript may be kept in reserve, in anticipation of novel conditions in which it may turn out to be more acceptable. Alternatively, the innovator may take his new subscript out of the script, in a spin-off, to experiment with new scripts outside the established order.

In terms of the example of self-service retailing, someone in a shop may have thought of letting an impatient customer, not in need of any advice from attendant, collect his own goods in the storage room, at a moment that there was a large crowd in front of his counter. Having experimented with this procedure a few times, he may have tried to convince his boss to allow for it more systematically, by opening up the storage room and putting goods on display. More likely than not, the shopkeeper would not have allowed for this strange move, with uncertain rewards and costs of re-arranging the shop, and the innovating attendant may have had the entrepreneurial spirit to leave and set up shop on his own. He would then have found out, step by step, what was needed to make the new arrangement work and develop a dominant design.

It took some time for the self-service formula to do this, in the development and use of new packaging and price tagging, design of shop lay-out, in space, shelves, colours and lighting, provision of shopping carts, and check-out technology for fast payment. Adapted technology and design of cooling and refrigeration were needed to incorporate fresh goods (fruit/vegetables, dairy products, meats), with a consequent need for cooling technology in trucks. Further development entailed changes in inventory management and ordering policy, later supported by scanning of bar codes. There were effects in increasing scale of shop units, concentration in franchising and chain stores, the use of loading bays, large units with parking space outside traditional city centres, new superscripts of supply, branding, production, packaging in the food industry, advertising, traffic, and changed power relations between producers and retailers. In this way lower change, on the subscript level of attending to customers, yielded a new retail script, and a

new superscript of supply, distribution and production. This illustrates how new institutions can arise from innovation 'from below'.

Most often, structural change is not that spontaneous from within, and change may be imposed from outside by institutional change. In terms of the retail example, after the breakthrough of self-service retailing, service shops had to adapt in order to survive. Here, structural change may be triggered 'from above'. For this, new skills (nodes with repertoires) are likely to be brought in from outside, in imitation of the emerging dominant design.

The innovation of self-service restaurants, that followed self-service retailing, entailed the reciprocation of self service from retailing into restaurants.

The retail example was one taking place in reality. Increasingly, with advances in IT, experiments with novel structures may be conducted virtually, in computer simulation.

Table 1 Types of change

Type of exploration						
Change	1a	1b	2a	2b	3	4
validation criteria	no	no	local	collective	collective	collective
repertoires of subscripts	no	yes	yes	yes	no	yes
script architecture	no	no	no	no	yes	yes

Table 2 Construction of new knowledge

Type of change						
Type of knowledge	1a	1b	2a	2b	3	4
validity of action	no	no	local	collective	collective	collective
location of capability (with tags)	no	local	local	collective	collective	collective
content of knowledge (causal beliefs)	no	local limited	local limited	collective limited	collective extensive	collective iterative
norms of conduct	no	no	local limited	collective limited	collective extensive	collective iterative
architecture of roles	no	no	no	no	yes	yes
collective enterprise	no	no	no	no	collective	collective extensive

Figure 1 Nesting of scripts

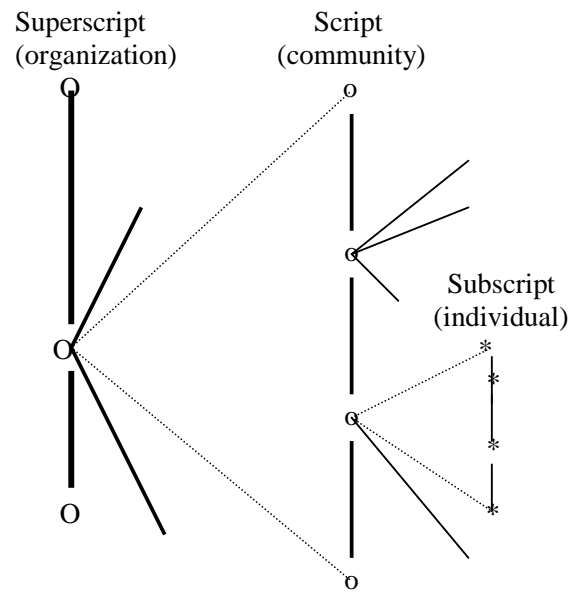
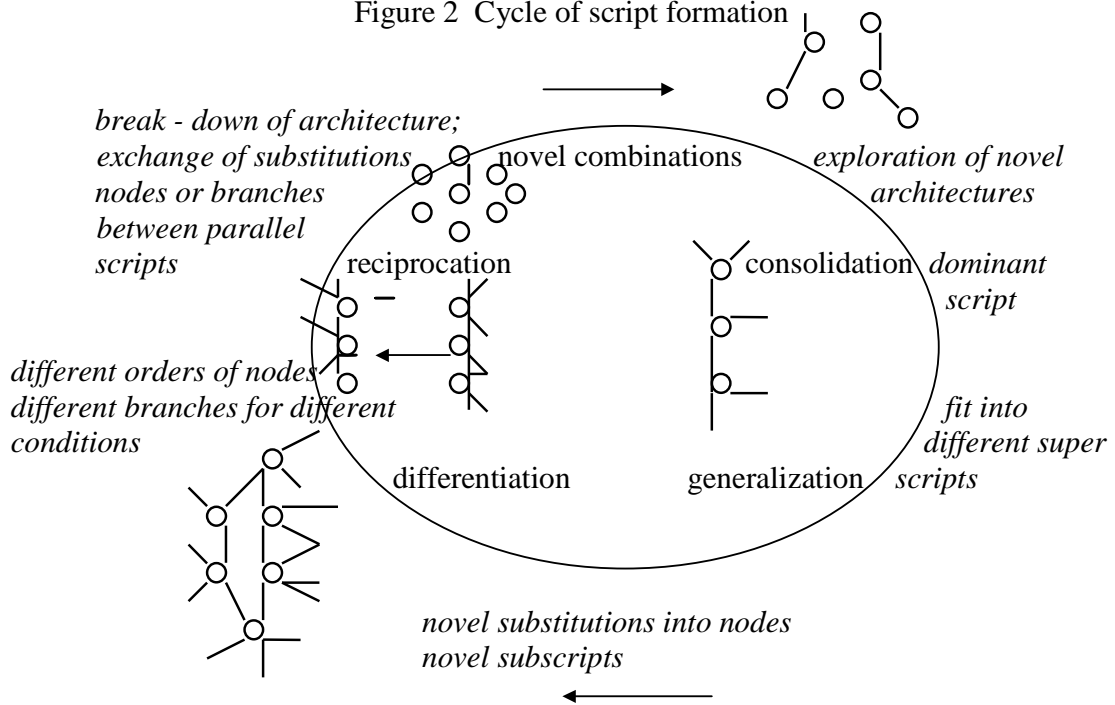


Figure 2 Cycle of script formation



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